



Innovative competency management tool

Herramienta innovadora de gestión de competencias

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ABSTRACT:

The article deals with the problem of creating innovative competency management tool concerning high-tech industries. The application of such tool and mechanisms provides an opportunity to ensure the active implementation of intellectual property in the economic and commercial turnover, as well as to form a proactive response in the operational and strategic management of the intellectual property of the organization to the market challenges faced by the enterprise. Creating the innovative competency management tool aims at maintaining the competitiveness of the organization, its products and services, as well as providing conditions for effective development, use, implementation, and attraction of organization's innovative competencies. The practical outcome of the article consists of a developed innovative competency management tool provided with a description of the step-by-step technique, the elements of which can be automated in the form of a software package.

Keywords: competencies, innovations, management systems

RESUMEN:

El artículo aborda el problema de crear una herramienta innovadora de gestión de competencias con respecto a las industrias de alta tecnología. La aplicación de dicha herramienta y mecanismos brinda la oportunidad de garantizar la implementación activa de la propiedad intelectual en la rotación económica y comercial, así como de formar una respuesta proactiva en la gestión operativa y estratégica de la propiedad intelectual de la organización a los desafíos del mercado enfrentados por la empresa. La creación de la herramienta innovadora de gestión de competencias tiene como objetivo mantener la competitividad de la organización, sus productos y sus servicios, así como brindar las condiciones para el desarrollo, uso, implementación y atracción efectiva de las competencias innovadoras de la organización. El resultado práctico del artículo consiste en una herramienta de gestión de competencias innovadora desarrollada que incluye una descripción de la técnica paso a paso, cuyos elementos se pueden automatizar en forma de un paquete de software.

Palabras clave: Competencias, innovaciones, sistemas de gestión

1. Introduction

The innovative competencies management is the process of forming competencies, their development (improvement) and use (application) for the design, production, and promotion of globally competitive products and services (Chursin, Makarov, 2015; Chursin et al., 2017; Ansoff, 2009; Sokół, Figurska, 2017; Girdzijauskaite et al., 2019).

The main purpose of managing the process of formation, development, and use of innovative competencies within the company is to organize the exchange of technologies, innovations, and other intellectual property. The exchange of competencies represents the implementation of mediation activities that ensure interaction between the owners and consumers of competencies in order to acquire the required competencies by consumers (Bocharov, 2012; Oganisjana et al. 2017; 2018).

A distinctive feature of this mechanism is that the subjects of the transaction are competencies, rather than products and knowledge in and of themselves, that is, the knowledge and ability of their owners to solve the problems of consumers in creating and producing competitive products and technologies.

The application of such mechanisms provides an opportunity to ensure the active introduction of intellectual property in the economic and commercial turnover, as well as to form a proactive response in the operational and strategic management of organization's intellectual property.

1.1. Problem statement

Our purpose of creating the innovative competency management tool is maintaining the competitiveness of the organization, its products and its services, as well as providing conditions for effective development, use, implementation, and attraction of organization's innovative competencies.

The objectives of the innovative competency management tool include:

- providing conditions for the creation, use, and implementation of innovative competencies;
- organizing and maintaining the proper functionality of the information database of certain competencies possessed by the organization in a form, which allows searching, selecting, and sorting competencies for the end user;
- providing regular diagnostics of existing competencies and solutions on the choice of innovative competencies selected for development;
- searching for new possible applications of the organization's competencies in foreign markets using the latest methods of market research.

The functions of innovation competencies management technique include the following items:

- describing the characteristics and functionality of the organization's innovative competencies;
- adding competencies in the competencies information database (Brodetsky, 2010);
- organizing the innovative competencies register of the organization, as well as mechanisms for its editing, sorting, searching, and providing various levels of access;
- providing information on existing innovative competencies to potential consumers;
- organizing interaction between the source and the consumer of innovative competencies;
- conducting an analysis of the dynamic pattern of the innovative competencies characteristics, collecting statistics on the demand for competencies;
- calculating performance indicators of innovative competency management mechanisms based on selected criteria;
- providing reporting data on the status and dynamics of the organization's innovative competencies development, as well as on the operation of innovative competency management mechanisms to the organization's management (Burkov et al., 1998).

The innovative competency management tool will contribute to the creation of systems providing:

- search and access to the organization's innovative competencies for end users;
- analytical processing of information on the use and development of innovative competencies within the organization;
- the attraction of competencies necessary for the organization in order to carry out activities and implement development plans;
- improvement of utilization effectiveness of innovative competencies of the organization (Burkov et al., 2008).

Competencies management tools are the means of preparation and implementation of managerial decisions. The tools are used for managerial impact when planning and controlling the use of quality characteristics and their numerical values established by the task with regard to the competency management object at a given time.

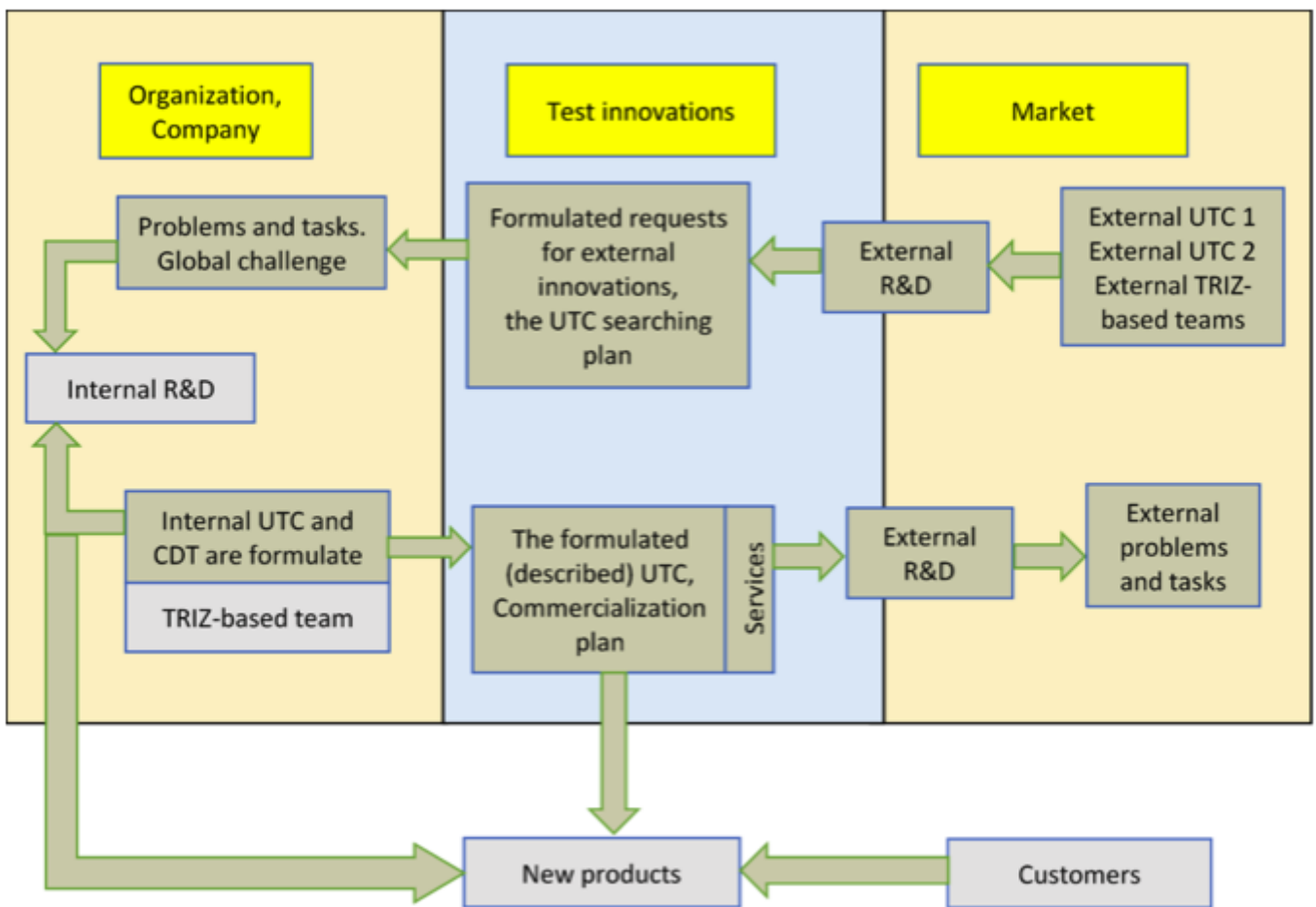
Research and practice of the competency-based approach have shown that the unique technological competencies, as the highest level of technological competency (UTC), are created (formed) by teams of specialists when solving nonstandard, new scientific and technical problems and tasks aimed at developing new technologies and products. In the course of these processes,

skills and approaches are developed not only to solve a specific, already implemented topic, but also a potential opportunity for this team of specialists to solve many new problems and tasks based on repeated use of their UTC in order to create new products and technologies in various fields of application.

2. Methodology

Thus, the existing problems and long-term tasks that are solved either by internal resources of the organization, primarily by scientific and technical specialists with appropriate technological competency within the framework of internal R&D, or external competencies, serve the basis for the creation of new UTC. In turn, it is the global challenges that are the fundamental basis to form new global tasks. The interaction pattern of internal and external UTC, problems and tasks is presented in Fig. 1:

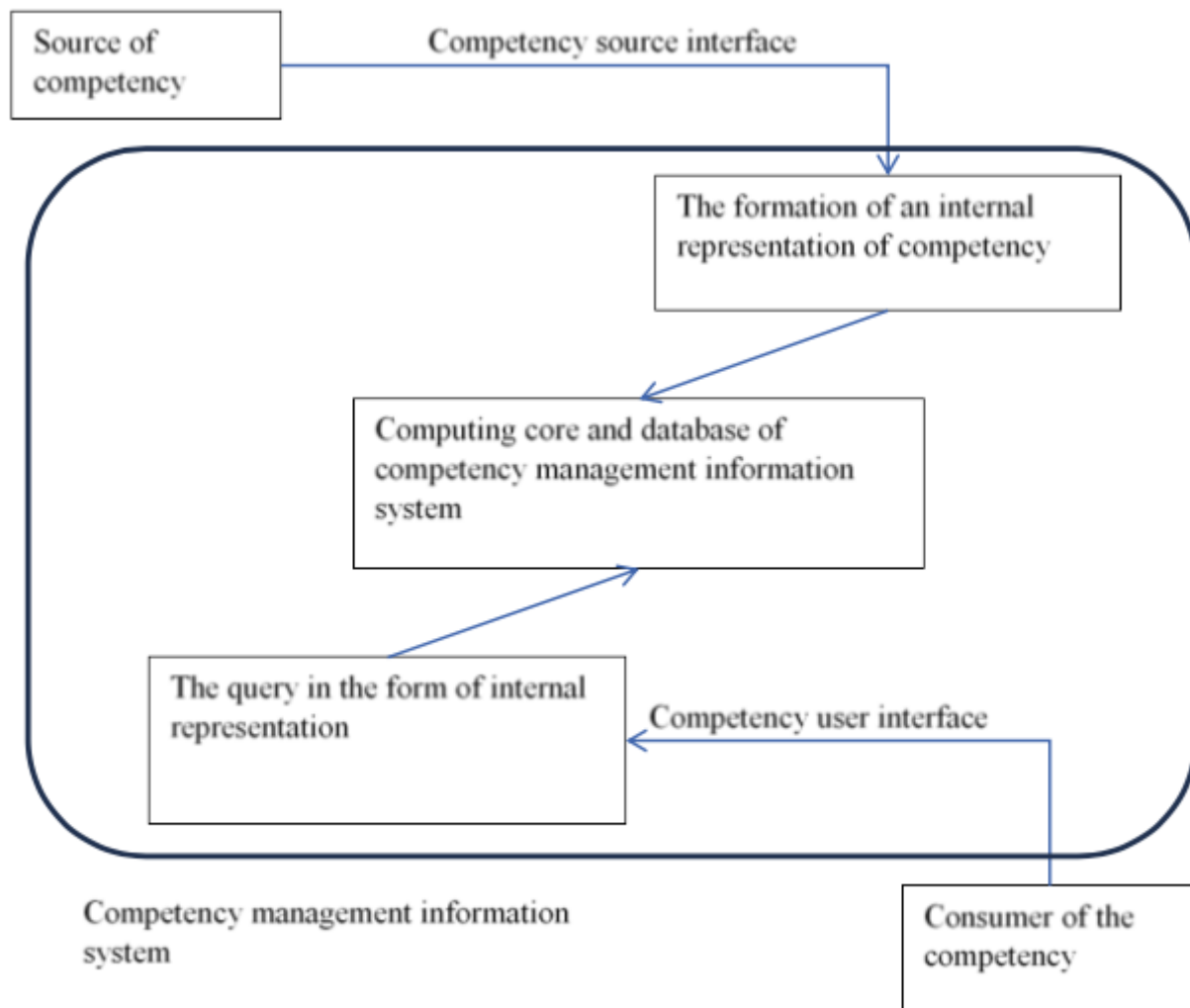
Figure 1
The interaction pattern of internal and external UTC, TRIZ (Theory of Inventive Problem Solving (Russian abbreviation TRIZ is internationally used)), problems, and tasks.



The presented interaction pattern shows that UTC is created within both the organization based on the solution of existing problems and objectives by the organization’s staff, who possess the technological competencies and have the potential to solve these problems and challenges and external UTC, which are outside the organization. At that, the UTC is created through the implementation of R&D as well as design and development work.

The interaction pattern reflecting the progression of competency from its source to the final user is presented in Fig. 2

Figure 2
Competency management information system.



The overall objective of such a system is to formalize and classify all competencies existing in the organization with the possibility of their dissemination.

Decomposition of the generalized process of competency management allows talking about the following basic processes in the mechanism:

- identifying competencies within the organization;
- formalizing competencies according to certain criteria and form;
- classifying and recording competencies in the information database;
- searching for competencies in the information database according to certain criteria;
- ranking competencies that are in the database, and meet certain specified criteria;
- organizing access to competencies;
- organizing interaction between the competency source and consumer;
- organizing competencies application methods.

The described approach considers the competency management information system as a special structural unit of the organization's corporate infrastructure, ensuring the collection, storage, and provision of relevant knowledge in order to obtain maximum benefit from them, as well as attracting the necessary missing knowledge to the organization.

Performance evaluation of innovative competency management tools should be based on a comparison of the results of the implementation of mechanisms with the goals and objectives that have been defined for these mechanisms. Given that the development and implementation of mechanisms for managing innovative competencies have several goals and objectives, it is advisable to consider the effectiveness of tools in each direction of the expected effect.

The development and implementation of innovative competency management mechanisms can lead to a reduction in direct costs for the development, refinement, and promotion of products, and, in particular, a reduction in R&D costs, as well as a reduction in the lead time of new products and technologies. The use of mechanisms such as crowdsourcing can improve the accuracy of demand forecasting for products and services, as well as financial forecasting. Improving the accuracy of products development and production planning can contribute to improving the accuracy of cash flow forecasting that can improve the economic, financial, and logistical performance of the organization.

The development and implementation of innovative competency management mechanisms can lead to an expansion in the range of products and services provided, as well as to an increase in their demand from the consumer, which can result in an increase in sales and market share of organization's products and services, and thus increase revenue and profit.

Use of innovative competency management mechanisms can lead to improvement of internal processes of the organization that will allow optimizing the use of resources of the organization and reduces the time required to search for the solution to the organization's problem. Also, the use of innovative competency management mechanisms can result in a systematic reduction of various organization risks (commercial, strategic, business, logistics, overproduction, etc.).

Ultimately, summarizing up the effects in all the above areas, the implementation of innovative competency management mechanisms has positive impact on the following integrated indicators of the organization:

- turnover indicators of the organization;
- profit indicators of the organization;
- the proportion of innovative products and services among all products and services produced by the organization;
- workforce productivity in the organization;
- utilization of fixed assets of the organization;
- the proportion of research effort and R&D costs in total costs of the organization;
- knowledge intensity coefficient of produced products;
- the market share occupied by the organization's products and services;
- the value of the organization's shares.

Currently, the following classification of competencies by their scope of application is supported in the world practice:

- technological competency;
- organizational competency;
- competency of technological cooperation (partnership);
- marketing competency (knowledge of latent demand);
- investment competency;
- competency of the inclusion of innovation in the corporate strategy;
- production competency;
- competency in the R&D area;
- competency of rapid acquisition of technological assets.

The only consistent method for implementing the aforementioned tasks is the development of a software package that implements the approaches described in the article. The stages of formation of technical requirements for software (before integration into existing systems for managing enterprises and holdings) may look as follows:

Stage 1. Definition of criteria and performance indicators of the software package for managing innovative competencies.

Stage 2. Modeling of objects and subjects of management of innovative competencies, as well as relationships between them.

Stage 3. Modeling of characteristics and functionality of innovative competency management tools.

Stage 4. Modeling of resources required to use innovative competency management mechanisms.

Stage 5. Implementation of information and analytical methods for collecting and storing, as well as changing and supplementing information on innovative competencies of an organization.

Stage 6. Implementation of information and analytical methods for the exchange of information on innovative competencies of an organization with sources of competencies, as well as end-users of competencies.

Stage 7. Software implementation of scenarios of the mechanism for managing innovative competencies.

Stage 8. Automated generation of reports on the work of mechanisms for managing innovative competencies for top managers of an organization, considering previously defined forms of storage and work with information on innovative competencies of an organization.

3. Results

Generation stages of innovative competency management mechanisms and expected results from their application

Practical management of innovative competencies is related to the issues concerning their identification and storage, involvement and dissemination, as well as their development. Creating a mechanism for managing innovative competencies is a step-by-step multistage process, the ultimate goal of which is the practical implementation of the necessary functionality for the innovative competencies management in the form of information and analytical system.

Generation of innovative competency management mechanisms consists of the stages considered below.

Stage 1. Definition of goals and objectives to generate mechanisms of innovative competencies management.

At this stage, it is necessary to determine the feasibility of developing and implementing the innovative competency management mechanisms, as well as identify goals and objectives, which will be achieved through the use of these mechanisms. It is also necessary to determine the scope of the organization's activities and specific indicators that will be affected by the use of the developed innovative competency management mechanisms. These may be indicators of different levels and content, such as operation indicators of units and groups within the organization, indicators reflecting the generation of intellectual property, characteristics, and functionality of products, the overall economic performance of the organization, etc.

Activities being undertaken at this stage are the following:

- defining and formalizing the objectives of the development and implementation of the innovative competency management mechanism;
- defining and formalizing the tasks of development and implementation of the innovative competency management mechanism;
- determining the expected outcomes resulted from the use of the innovative competency management mechanism;
- determining the criteria to assess the utilization results of the innovative competency management mechanism.

Stage outcomes are as follows:

- formalized goals and objectives of the development and implementation of the innovative competency management mechanism;
- formalized criteria of application of the innovative competency management mechanism;
- formalized criteria to assess the utilization results of the innovative competency management mechanism.

Stage 2. Definition of management factors (management objects and subjects, as well as their connections), and concept formation of the competency management information system.

At this stage, it is necessary to formalize the management objects, namely, innovative competencies, as well as other participants of the competency management mechanism, such as the consumer of competencies, the source of competencies, and the operator of the management mechanism. That is, the task arises concerning the formal description and generalization of information about the existing competencies of enterprises of knowledge-intensive industries. To do this, it is necessary to define the basic criteria describing innovative competencies within the framework of the competency management mechanism.

Objectives of the stage are as follows:

- to form a list of characteristics that are necessary and sufficient to describe all possible properties and functionality of innovative competencies, for which a competency management mechanism is generated;
- to determine the algorithm and rules describing characteristics and functionality of innovative competencies;
- to prepare information content for the survey in order to create the competencies concept and prepare information about competencies for processing and use within the mechanism of innovative competencies management.

Stage outcomes are as follows:

- a set of criteria that can be measured numerically or logically, allowing creating a representation of competency, which includes all the characteristics and functionality that are important for consumers of innovative competencies;

- tools for creating an information representation of competencies for their use in the framework of the innovative competency management mechanism;
- the concept of interaction between the competency source and consumer based on the use of information and management relationships of emerging innovative competencies management mechanism.

Stage 3. Definition and description of the characteristics and functionality of the tools used in the generated innovative competency management mechanism.

Organization of interaction between competency sources and consumers requires some of specially developed tools that allow forming the image of competencies, conducting their information analysis of various nature, and providing communication between competency management objects and subjects. Such tools may include the competency describing the procedure, assessment of competency, ranking and identification of key competencies, search among competencies, and many other things. This requires the definition and description of information links, objects, and subjects of management in the competency management mechanism.

Objectives of the stage are as follows:

- defining subjects and objects of the innovative competency management mechanism;
- defining characteristics of subjects and objects of the innovative competency management mechanism;
- defining types of interaction between subjects and objects of the innovative competency management mechanism;
- defining information connections between subjects and objects of innovative competency management mechanism;
- defining the operation flowchart of the innovative competency management mechanism;
- developing the operation algorithm of the innovative competency management mechanism.

Stage outcomes are as follows:

- operation flowchart of the innovative competency management mechanism, as well as its graphical representation;
- formalized description of all types of competency management mechanism elements, including their possible characteristics, functions, and interaction options.

Stage 4. Identification of resources necessary for the use of innovative competency management mechanisms (material, technical, financial, social, institutional, and other resources, required to implement selected management method and achieve the set goal).

At this stage, it is necessary to determine resources inside and outside the organization, which are required to ensure the functioning of the competency management mechanism. It is necessary to classify them, as well as to determine their cost and risks associated with their use. It is also necessary to consider possible alternatives to the resources used.

Objectives of the stage are:

- identifying and describing the resources necessary for the functioning of the competency management mechanisms;
- classifying and structuring the resources necessary for the functioning of the competency management mechanisms;
- considering alternative resources, which can be used in competency management mechanisms.

Stage outcomes are as follows:

- information structured database of resources necessary for the functioning of the competency management mechanism, which includes direct information about the resource (type, volume, purpose, etc.), as well as the cost of attracting this resource, and the risks associated with its use.

Stage 5. Determination of information and analytical methods of collection and storage, changes and additions of information about the innovative competencies of the organization, as well as technical characteristics of the practical implementation of the generated innovative competency management mechanism.

Objectives of the stage are:

At this stage, it is necessary to select the methods of collecting, storing, and processing information about the organization's innovative competencies.

The requirements formalization process with respect to the practical implementation of the formed innovative competency management mechanism is necessary for:

- analysis of the structure and amount of information circulating in the system;
- identification of surplus information;
- elimination of duplication;
- information compression;
- reduction of labor intensity.

Requirements for the practical implementation of the generated innovative competency management mechanism include the following:

- minimum redundancy;
- use for the maximum number of applications or tasks;
- independence from the processing program;
- reliability of data;
- privacy of information;
- protection against distortion and destruction;
- minimum processing cost;
- ability to develop and adapt.

Stage 6. The definition of information and analytical methods of the exchange of information about the innovation competency of the organization with sources of competencies, as well as with the end users of the competencies.

At this stage, it is necessary to determine the interaction order and form of the innovative competency management mechanism with the source and the consumer of innovative competencies.

Objectives of the stage are:

- determining the form, procedure, and work schedule of the innovative competencies sources in the framework of the innovative competency management mechanism;
- modifying algorithms for the transformation of unstructured information about innovative competencies from sources of competencies to the form applicable in the information and computer system of the innovative competency management mechanism;
- determining the form, procedure, and work schedule of the end users of innovative competencies in the framework of the innovative competency management mechanism;
- modifying the transformation algorithms of unstructured information about the requested innovative competencies from the consumers to the form applicable in the information computation system of the innovative competency management mechanism.

Stage outcomes are:

- a set of forms and proper operating algorithms, compatible with the information and computer representation of the innovative competency management mechanism, which will be used to communicate with the source of competency;
- a set of forms and operation options, compatible with the information and computer representation of the innovative competency management mechanism, through which communication with the end user of competencies will be carried out.

Stage 7. Definition of operation scenarios of the innovative competency management mechanism.

At this stage, it is necessary to carry out modeling and describe possible scenarios of the innovative competency management mechanism.

Objectives of the stage are:

- defining and describing the scenarios of the innovative competency management mechanism;
- developing instructions and regulations for all participants of the mechanism operating in the regular mode;
- identifying and describing possible abnormal situations in the operation of the innovative competency management mechanism;
- developing instructions and regulations for all participants of the innovative competency management mechanism.

Stage outcomes are:

- a set of possible scenarios of regular work of the innovative competency management mechanism, as well as documents regulating the procedure for each of the mechanism participants;
- a set of possible abnormal situations, which may arise in the course of operation of the innovative competency management mechanism, as well as documents regulating the procedure for each of the mechanism participants.

Below is described the management process of unique competencies using a mathematical model. The following types of innovative competencies are considered with appropriate economic indicators:

- Technological competencies **A** (coefficient of development of new technology, K_{td} ; coefficient of innovation growth, K_{ig});
- Production competency **B** (indicators of production resource conservation, K_{res} ; the indicator of the viability of the project within the given timeframe, K_{viab});
- Research competency **C** (coefficients of the assets intended for R&D, K_{RD} ; coefficients of company personnel engaged in R&D, K_{per});

Next, a dynamic system is described that allows simulating different scenarios of competency management.

Since further a dynamic model will be considered, it is necessary to introduce the time in this model. Usually, in economic models, discrete time is considered, because many processes develop over a long time, however, for qualitative results, it is convenient to consider continuous time since in this case obtained mathematical models are more compact. Note that, if necessary, it is always possible to obtain a discrete model based on a mathematical model with continuous time. Thus, the processes with continuous time (**t**) will be considered.

Consider the case of a finite time interval, which is quite sufficient for the proposed model.

The values **A(t), B(t), C(t), D(t)** describe a dynamic model of innovative competencies management.

The system of differential equations describing the dynamic system has the form:

$$\begin{cases} \dot{A}(t) = F(A, B, C, D) \\ \dot{B}(t) = F(A, B, C, D) \\ \dot{C}(t) = F(A, B, C, D) \end{cases}$$

When constructing the formal bases for economic and mathematical models, it is necessary to choose the main numerical characteristics to describe the corresponding economic quantities. We will consider dimensionless quantities, which qualitatively describe the state of economic quantities. Therefore, numerical values of functions represent values of integral indicators to describe the level of the considered competencies.

The specific values of these indicators of innovative competencies may not have a specific economic meaning since the economic importance consists in comparing these values. For example, one can say that the level of competency at a time t_1 is higher (lower) than that at a time t_2 .

The dynamics of the values under consideration, which describe innovative competencies, can be described by the following system of linear differential equations:

$$\begin{cases} \frac{dA}{dt} = \alpha_0 A(t) + \alpha_1 C(t), \\ \frac{dB}{dt} = \beta_0 B(t) + \beta_1 A(t), \\ \frac{dC}{dt} = \gamma_0 C(t) + \gamma_1 B(t) \end{cases}$$

In these equations, each dynamic variable has a certain coefficient $\alpha_i, \beta_i, \gamma_i$ that reflects the objective reduction of all indicators over time in view of the overall development of the economy and scientific and technological progress, if there is no management of innovative competencies.

In the described model, the coefficient of technological competencies increases under the influence of the coefficient of research competencies; the coefficient of production competencies increases under the influence of technological competencies, while the coefficient of research competencies increases under the influence of production competencies. Management of innovative

competencies in the framework of this scenario allows developing simultaneously the entire set of competencies, and at the same time increasing the proper indicators describing them.

External influence describing the innovative competencies management, as well as the impact of random factors can be described using heterogeneous coefficients ε . These coefficients describe the qualitative nature of changes in the innovative competencies indicators that occur in consequence of the implementation of measures to manage innovative competencies. The system of differential equations taking into account the control actions can be written as follows:

$$\begin{cases} \frac{dA}{dt} = \alpha_0 A(t) + \alpha_1 C(t) + \varepsilon_A, \\ \frac{dB}{dt} = \beta_0 B(t) + \beta_1 A(t) + \varepsilon_B, \\ \frac{dC}{dt} = \gamma_0 C(t) + \gamma_1 B(t) + \varepsilon_C \end{cases}$$

The system of differential equations describing the dynamics of innovative competencies indicators can be solved by one of the standard methods, for example, the Runge-Kutta method of the 4th order. Since this model describes the dynamics of innovative competencies in time, the initial values of the competency indicators can be taken equal to unity:

$$A(0) = 1, B(0) = 1, C(0) = 1$$

Thus, in the presence of initial values of the innovative competencies dynamics model, the simulation modeling of the innovative competencies management process can be carried out.

As a result of modeling, optimal scenarios of innovative competencies management can be selected based on the criteria described in the next stage.

Stage 8. Definition of criteria and development of methods to determine the performance efficiency of innovative competency management mechanisms

At this stage, the performance efficiency of innovative competency management mechanisms is assessed based on the following system of standard economic indicators of the organization:

- coefficient of new technology development, Ktd;
- coefficient of innovation growth. Kig;
- indicator of production resource conservation, Kres;
- indicator of the viability of the project within the given timeframe, Kviab;
- coefficient of the assets intended for R&D, KRd;
- coefficient of company personnel engaged in R&D, Kper;

For strategic planning, the organization can build predictive trajectories of changes in these indicators. With a significant deviation of the actual values of indicators from the forecast, one can talk about the inefficient management of technological competencies and the need for strategic decision-making.

Stage 9. Definition of reporting techniques about the operation of innovative competency management mechanisms for organization executives, taking into account previously defined forms of storage and work with information on innovative competency of the organization, as well as criteria for assessing the effectiveness of innovative competency management mechanisms.

At this stage, it is necessary to develop forms and regulations for reporting on the operation of both the innovative competency management mechanism in general and specifically the constituent tools. Such reports will have to be generated in a special form approved by the management of the organization based on up-to-date database information. These reports can be presented in both electronic form, as a sample retrieved from the information database, and in the printed version.

Objectives of the stage are as follows:

- defining a set of documents of various types necessary for reporting on the operation of innovative competency management mechanism, to be presented to the management of the organization at various levels;

- developing and defining the forms and layouts of reports on innovative competency management mechanisms based on their content and purpose.

Stage outcomes are as follows:

- approved sets of reporting forms on the operation of innovative competency management mechanisms according to their purpose;
- algorithms for reporting on the operation of innovative competency management mechanisms according to their purpose.

4. Conclusions

The present work offers the innovative competencies management algorithm representing actions and tools to form competencies, their development (improvement) and use (application) for design, production, and market promotion of globally competitive products and services.

All mathematical calculations and algorithm techniques can be effectively implemented in the form of computer programs.

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